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Vegetation, Peat Elevation and Peat Depth on Two Tree Islands in Water Conservation Area 3-A

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Abstract

Vegetation (species composition and cover abundance) and peat and bedrock elevations were sampled along multiple transects across the head, near tail and far tail of two tree islands (designated the North Island and South Island) in Water Conservation Area 3-A. The heads of both islands are underlain by topographic highs in the bedrock. The peat layer was thinnest on the heads and much thicker on the near tail and far tail. The thinner peat layer on the heads of tree islands suggests that there is a mechanism that limits the maximum elevation of a tree island. Altogether 84 and 51 species were found on North Island and South Island, respectively. The results of an agglomerative hierarchical cluster analysis indicated that there were 9 and 7 plant assemblages on North Island and South Island, respectively. Although sometimes dominated by different species, the 7 assemblages on South Island had ecologically equivalent counterparts on North Island. Three plant assemblages (dry forest, wet forest, forest-fem) dominated by trees and shrubs (Chrysolalanus icaco (coco plum), Myrica cerifera (wax myrtle), Salix caroliniana (Carolina willow), and Schinus terebinthiflolius (Brazilianpepper)) were found primarily on the heads of the islands, which had the highest peat and bedrock elevations, and sometimes on the adjacent near tail. Sawgrass (Cladiumjamaicense) dominated plant assemblages (sparse sawgrass, dense sawgrass, decadent sawgrass, sawgrass-cattail) and wet prairie (Eleocharis cellulosa Torr. and Panicum hemitomon Schult.) were found at lower peat elevations and slough assemblages (Bacopa caroliniana, Eleocharis cellulosa, Nymphaea odorata, Utricularia purpurea) were found at the lowest peat elevations. There generally was no clear-cut relationship between bedrock or peat elevations and the distribution of the various sawgrass and wet prairie assemblages.

Keywords

Everglades, fixed tree island, Florida, peat thickness, bedrock elevation, peat elevation

Disciplines

Botany | Ecology and Evolutionary Biology | Terrestrial and Aquatic Ecology

Comments

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Chapter 11

Vegetation, Peat Elevation and Peat Depth on Two Tree Islands in Water Conservation Area 3-A

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1. INTRODUCTION

In the Florida Everglades, two types of tree islands are recognized; floating tree islands and fixed tree islands (Davis 1943; Loveless 1959; Gleason and Stone 1994; Wetzel 2001). Floating tree islands are associated with areas of deep peat and are common in the northern portions of the Everglades, especially the Loxahatchee National Wildlife refuge (Gleason et al. 1980; Brandt et al. 2003). Unlike floating tree islands, which can pop-up anywhere, fixed tree islands are assumed to be associated with topographic highs in the bedrock around which these islands develop (Loveless 1959).

Fixed tree islands have three characteristic features: 1) they are teardrop shaped and their long (north-south) axis is parallel to surface-water flows; 2) the tallest trees and shrubs are found at the upstream end of the island, the head, which is typically the widest and highest part of the island; and 3) behind the head there is an elongated v-shaped area, the tail, with a lower elevation than the head. The vegetation of the tail is dominated by shrubs or marsh species (e.g., sawgrass or typha), or a combination of the two. The heads are believed to have originated as topographic highs in the bedrock. Today the heads are covered with a layer of peat. How much of the elevation of heads is due to the underlying topographic highs and how much to peat accumulation patterns is unknown. The characteristic teardrop shape of these tree islands is believed to be due to the development of a "tail" behind the head due to the accumulation of peat. Two hypotheses for the accumulation of peat behind heads have been proposed: 1) a higher rate of primary production behind heads due to leaching of nutrients from the head that results in higher peat deposition rates; and 2) peat eroded from the head is deposited in the lee of the heads by water currents, especially during hurricanes. Fixed tree islands are common in the Water Conservation Areas, WCA-2A, WCA-3A, and WCA-3B and in Everglades National Park.

Little is known about how fixed tree islands develop. The few studies that have been conducted on fixed tree islands have focused on their persistence (Shortemeyer 1980), utilization by animals (Gawlick and Rocque 1998; Shortemeyer 1980; Bancroft et al. 1994) and paleoecology and peat stratigraphy (Stone et al. 2003; Willard et al. 2003). Vegetation analyses on tree islands have been focused on vegetation and associated bedrock and peat topography on the highest portion of the islands (Shortemeyer 1980; Davis 1943; Worth 1983, 1988; Zaffke 1983; Meeder et al. 1996; Olmsted and Armentano 1997; Heisler et al. 2003). There have been no studies of the vegetation and geomorphology of entire tree islands (heads and tails),

In this chapter, we report on the results of a study of the vegetation, peat elevation and bedrock elevation of two tree islands. These two islands are part of a larger study of tree islands that is being conducted by the South Florida Water Management District. The primary purpose of our study was to examine the relationship between peat and bedrock elevation and the distribution of different plant assemblages. We hypothesized that the following features characterize fixed tree islands: 1) topographic or bedrock highs underlie the island heads; 2) the peat layer is thicker on the tail than on the head; and 3) the distribution of plant assemblages is related to either peat elevation or depth.

2. METHODS

2.1 Island Selection

Two tree islands were selected for study in water conservation area 3A. These islands were chosen because they had the classic teardrop shape; they were not close to canals, dikes, and other islands and they appeared to be free of recent disturbance, especially on the heads. One island was north of Interstate 75 (Alligator Alley) and one island was south of it (Figure 11-1, chapter 1 this volume). These islands are a subset of a set of islands selected as part of a larger study. In this larger study the islands are referred to as 3AN1 and 3AS4. In the interest of convenience, in this chapter they will be referred to as North Island and South Island, respectively.

2.2 Field Sampling

For the purpose of sampling, each tree island was divided into three zones as follows: head, near tail and far tail. The near tail zone is the zone immediately south of the head. It is distinguishable from the head in the field because the shrubs and trees in this zone are shorter and less dense than on the head. The far tail is dominated by sawgrass rather than by shrubs. Scattered individuals of a number of shrubs, e.g., *Cephalanthus occidentalis* L., however, are found on the far tail. Along each island's long axis, the head was divided into 5 equal subzones and the near tail and far tail into 3 equal subzones each. These subzones are bands running perpendicular to the long axis of the island and into the adjacent vegetation on both sides. Within each subzone, a west to east transect was selected at random. This transect ran perpendicular to the long axis of the island and extended 20 to 30 meters beyond the *Cladium jamaicense* Crantz fringe on both sides of the island.

Along transects, herbaceous vegetation was sampled in a series of contiguous 2x1 m quadrats, and woody vegetation in contiguous 4x5 m quadrats. In each quadrat, a complete species list was compiled and the cover of each species estimated using a modified Domin-Krajina cover-abundance scale (Mueller-Dombois and Ellenberg 1974). At 2 m intervals along the base line, water depth and depth to bedrock were measured. Water depth was measured to the nearest cm with a meter stick. Depth to bedrock was measured with a galvanized, 0.6 cm diameter rod that was marked in 1 cm increments. The rod was pushed through the peat to the bedrock. When a rubble or marl layer was present, care was taken to work the rod through these layers to the bedrock. Water depth and bedrock depth were collected along transects 1 to 4 and 6 to 11. The nomenclature used in this chapter is based on Wunderlin (1997).

2.3 Data Analyses

Elevations of the bedrock and peat layer were based on water level at mean sea level (msl) the day that water depth was measured. Absolute water level data from U.S. Geological Survey station number 261023080443001 site 62 for North Island and station number 254848080432001 site 65 for South Island were used to convert water depth and peat depth measurements to estimates of absolute peat and bedrock elevation. When both of these islands were sampled, nearly the entire island was underwater. Peat elevations of only 14 points on North Island and 7 points on South Island were above water. In these cases, the estimated height of the peat above water was added to the absolute water level.

Bedrock and peat surfaces were modeled using wire diagrams generated by Surfer^{tm} software (Golden Software Inc., Golden CO, USA). Wire diagrams of elevations are normally generated from a regular grid of elevation measurements (Surfer 1999). Our elevation data were collected along irregularly spaced transects not regular grids. Consequently, for elevations interpolated between transects, there are no confirming data. Based on our field observations, these elevation models do seem to provide a reasonable picture of the overall topography of these islands. Nevertheless, minor topographic features between some transects are missing.

An agglomerative hierarchical cluster analysis in the Statistica^{tm} software package (Statsoft Inc. Tulsa OK, USA) was used to delineate plant assemblages. Data from the two herbaceous quadrats nested within each woody quadrat were combined with a cover value assigned to each species that was the average of the midpoints of the cover intervals in the original quadrats. Data from the head were analyzed separately from data from the near tail and far tail. Software restrictions, however, allowed only 300 quadrats to be used in the analyses. For North Island, because of this software limitation, transect 7 was not included in analyses of near tail data.

Distances between quadrats were computed using city-block distance (Hartigan 1975) and then linked using Ward's method (Ward 1963). In dendrograms, plant assemblages were comprised of quadrats linked into clusters at a linkage distance of 50% or lower. For species present in each plant assemblage, an importance value, defined as the sum of its relative cover and relative frequency, was calculated. Species with the highest importance values, up to 50% of total importance, were designated as the dominant species.

When feasible, the names of plant assemblages identified in this study were taken from the published literature on Florida plant communities. These names are slough, wet prairie, sparse sawgrass, dense sawgrass, and decadent sawgrass (Davis 1943; Egler 1952; Goodrick 1984; Gunderson 1994; Loveless 1959, Alexander and Crook 1974). Decadent sawgrass is a vegetation assemblage in which sawgrass litter has the highest cover. Plant assemblages for which there were no published counterparts were designated sawgrass-cattail, forest-fern, dry forest, and wet forest.

One-way analysis of variances (ANOVAs) were used to determine differences in mean species richness and plant cover among plant assemblages and to determine if there were any differences among assemblages in mean peat elevation, peat thickness and bedrock elevation. When an ANOVA indicated a significant difference among assemblages ($P \leq 0.05$), Student-Newman-Keuls tests (Steele and Torrie 1960) were used to determine which means were significantly different. The Jaccard Index (Mueller-Dombois and Ellenberg 1974) was used to estimate similarity in the flora, species absence and presence, between islands and among zones within an island.

3. RESULTS

3.1 Topography

Graphical representations of bedrock and peat topography for North Island are given in Figure 11-1. Overall, the average bedrock elevation of the North Island was 261 cm and ranged from 94 to 366 cm. Mean bedrock elevation was highest on the head, 288 cm, and lowest on the near tail, 240 cm (Table 11-1). Mean bedrock elevation on the far tail was 252 cm, which was significantly lower than on the head and higher than on the near tail. The head of this island was underlain by a bedrock pedestal of approximately 2.2 hectares. The pedestal ranged from 66 to 140 m in width and 304 to 366 cm in elevation. On the western perimeter of the pedestal, extending the full length of the head, there was a trough (170 to 275 cm) ranging from 64 to 84 m in width. At the near tail, the trough turned east and became wider (66 to 192 m) and deeper (94 to 275 cm). The trough extended south to transect 10 where it became shallower and harder to distinguish (Figure 11-1).

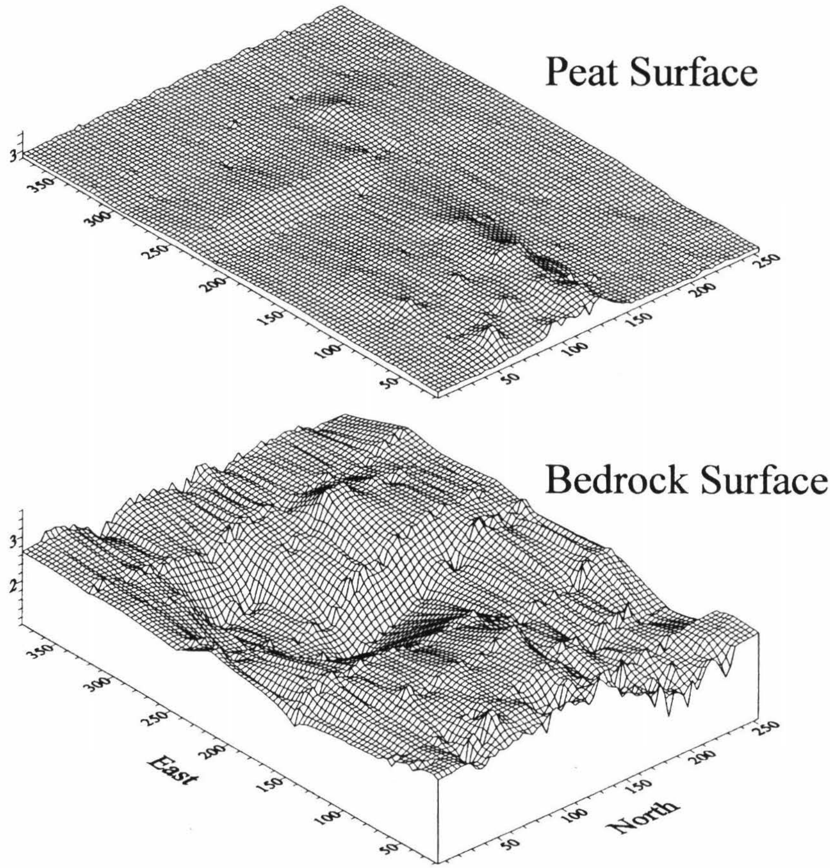

Figure 11-1. Graphical representation of bedrock and peat topography of the North Island. The scale is in meters. As explained in Methods, the general topographic trends of the wire diagrams are real but the specific topographic details are not (the Z scale is exaggerated by a factor of 30X).

Mean peat elevation of North Island was 324 cm and ranged from 291 to 366 cm. Average peat elevation declined from the head to the far tail with mean peat elevations of 330 cm, 325 cm and 317 cm, on the head, near tail and far tail, respectively (Table 11-1). The peat layer on North Island was thinnest on the head, 41 cm, and thickest on the near-tail, 84 cm. Peat thickness on the tail was 65 cm.

Table 11-1. Mean (standard deviation) of bedrock elevation, peat elevation, and peat thickness for the head, near tail and far tail of North Island and South Island. Significant differences among means are as indicated by different letters. ($p \leq 0.05$).

Island	Sample Points	Elevation of Bedrock (cm)	Elevation of Peat (cm)	Thickness of Peat (cm)
North Island				
Head	398	288 (40.6) a	330 (17.4) a	41 (30.0) a
Near Tail	368	240 (59.3) b	325 (8.5) b	84 (58.3) b
Far Tail	345	252 (40.2) c	317 (5.5) c	65 (38.5) c
Entire island	1111	261 (51.8)	324 (12.9)	63 (47.2)
South Island				
Head	200	176 (42.6) a	255 (27.4) a	83 (28.3) a
Near Tail	291	149 (10.5) b	252 (16.0) a	103 (17.9) b
Far Tail	307	149 (13.7) b	247 (9.2) b	97 (17.5) c
Entire Island	798	156 (26.4)	251 (18.0)	96 (22.3)

Graphical representations of bedrock and peat topography for South Island are given in Figure 11-2. Overall, the mean bedrock elevation was 156 cm and ranged from of 92 to 317 cm. Mean bedrock elevation was highest on the head, 176 cm, (Table 11-1). Mean bedrock elevation, (ca. 150 cm), was similar on the far tail and near tail. South Island's bedrock pedestal was bordered on the east and west by poorly defined troughs. The pedestal was approximately 0.2 hectare. Its width varied from 36 to 56 m and its height from 174 to 317 cm. The troughs ranged from 6 to 46 m in width and 92 to 155 cm in depth (Figure 11-2). The bedrock pedestal of North Island had approximately 11 times the surface area of that of South Island and was relatively higher, when compared to the surrounding bedrock, then that of South Island.

Mean peat elevation of South Island was 251 cm and ranged from 200 to 318 cm. Mean peat elevation declined from the head, 255 cm, to the near tail, 252 cm, and was lowest on the far tail, 247 cm (Table 11-1). The peat layer was thinnest on the head, 83 cm, thickest on the near tail, 103 cm, and in-between on the far tail, 97 cm. For both islands, elevation differences between heads and tails in bedrock topography are attenuated at the surface by the uneven deposition of peat over the islands.

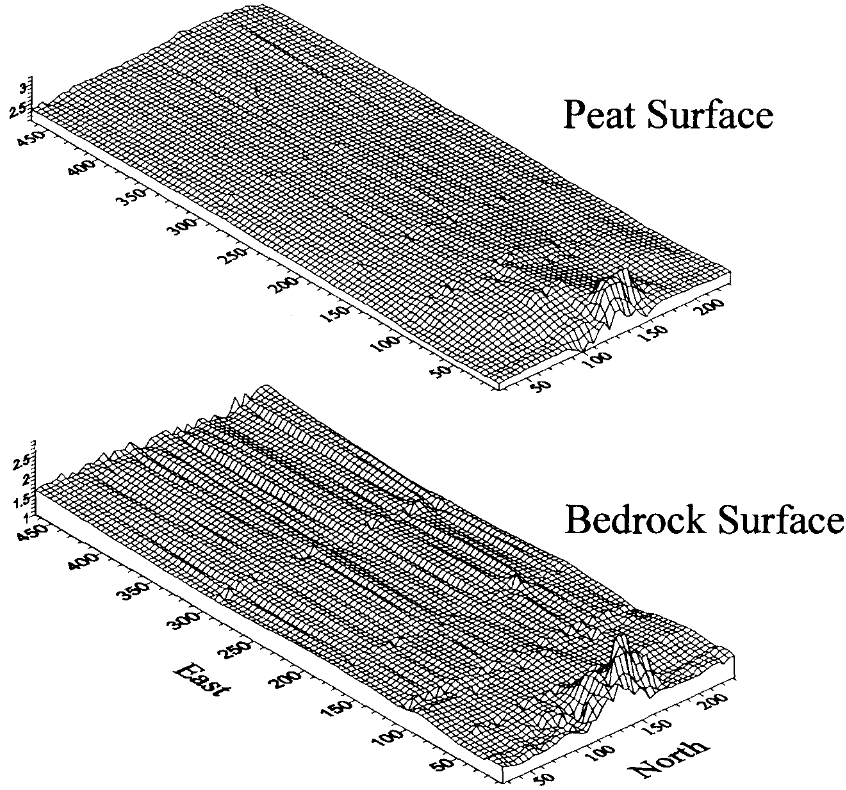

Figure 11-2. Graphical reresentation of bedrock and peat topography of South Island. The scale is in meters. As explained in Methods the general topographic trends of the wire diagrams are real but the specific topographic details are not (the Z scale is exaggerated by a factor of 30X).

3.2 Flora

Eighty-seven species were found on North Island. A complete list for both islands can be found in Mason and van der Valk (2001). A total of 78 species were found on the head, 58 on the near tail, and 41 on the far tail (Table 11-2). Mean species richness, expressed as the number of species found in a 4 m^{-2} quadrat, declined from 8.0 on the head, to 6.6 on the near tail, to 4.8 on the far tail (Table 11-2). All species, except *Echinochloa crusgalli* (L) P. Beauv., were perennials. Perennial forbs/herbs were the most common plants in all three zones (Table 11-2). Thirty-five species were common to the head, near tail and far tail. The Jaccard similarity indices between the head and near tail, head and far tail, and near tail and far tail were 26%, 24% and 28%, respectively.

Table 11-2. Summary of vegetation characteristics for each tree island by zone, including number of species representing each vegetation growth form; the total number of species; mean (standard deviation) species richness and total plant cover (per 4 m^{-2} quadrat). Significant differences in mean species richness and total plant cover between islands and among zones are indicated by different letters ($p \leq 0.05$).

	Number of species representing each plant type					
Vegetation Type	**North Head**	**North Near tail**	**North Far tail**	**South Head**	**South Near tail**	**South Far tail**
Tree	6	6	4	11	7	4
Shrub	1	1	1	2	1	1
Vine(woody or herbaceous)	8	6	3	4	3	1
Perennial forb/herb	30	21	15	9	8	6
Annual forb	0	1	0	0	0	0
Perennial Grass	10	9	8	6	5	5
Annual Grass	1	1	0	1	1	0
Sedges/Rushes	11	6	4	2	3	1
Free floaters/floating leaf	5	5	6	5	6	5
Non-flowering(ferns)	6	2	0	5	3	1
Total Species	**78**	**58**	**41**	**45**	**37**	**24**

Island	**No. of Quadrats**	**Richness**	**Total Cover**
North island head	192	8.0 (4.55) a	71.7 (22.92) a
North island near tail	120	6.6 (4.08) b	80.8 (18.18) b
North island far tail	170	4.8 (2.17) c	90.4 (18.79) c
South island head	97	7.9 (3.05) a	69.9 (22.29) a
South island near tail	143	6.9 (2.42) b	77.6 (22.90) b
South island far tail	146	5.5 (2.70) c	78.6 (19.31) b
North island	482	6.5 (3.99) a	80.6 (23.6) a
South island	386	6.6 (2.85) a	76.1 (21.7) b

Fifty species were found on South Island. Forty-five, 37 and 24 species (Table 11-2) were observed on the head, near tail and far tail, respectively. There was a significant decline in species richness from the head, 7.9 species per quadrat, to the near tail, 6.9, and to the far tail, 5.5 (Table 11-2). Again, all species except *E. crusgalli* were perennials. Trees, perennial forbs/herbs, perennial grasses and free floaters/floating leaf were the most common plant types on the head, near tail and far tail (Table 11-2). Twenty-one species were common to the head, near tail and far tail. The Jaccard similarity indices between the head and near tail, head and far tail, and near tail and far tail were 27%, 23% and 27%, respectively.

Fifteen woody species, vines, shrubs and trees, were recorded on the head of South Island while only ten woody species were present on North Island. Six woody species were common to both islands resulting in a Jaccard similarity index of 48%. There were more trees of tropical origins [*Bursera simaruba* (L.) Sarg., *Sabal palmetto* (Walter) Lodd. Ex Schult. and Schult. f., *Ficus aurea* Nutt., *Eugenia axillaris* (Sw.) Willd., *Annona glabra* (L.) and

Chrysobalanus icaco (L.)] on South Island, than on North Island (*S. palmetto*, *A. glabra* and *Schinus terebinthifolius* Raddi).

3.3 Plant Assemblages

In spite of the relatively low relief of these islands, 16 plant assemblages were found (Tables 11-3 and 11-4), including nine on North Island, which had more surface relief, and seven on South Island.

Table 11-3. Relative assemblage frequency, total species richness, and mean total cover of all species, for plant assemblages on the North Island. Mean cover (%), relative frequency (%) and importance value of dominant species are also given.

Assemblage	Frequency	Total Species Richness	Mean Total Cover:	Dominant Species	Cover (%)	Frequency (%)	Importance
Dry Forest	6%	30	86%	*Schinus terebinthifolius*	55	96	80
				Myrica cerifera	6	48	15
				Saururus cernuus	2	70	14
Wet Forest	4%	46	78%	*Myrica cerifera*	42	100	64
				Schinus terebinthifolius	5	63	12
				Hyptis alata	3	50	9
				Saururus cernuus	4	44	9
				Cladium jamaicense(live)	4	31	9
Forest Fern	6%	56	46%	*Thelypteris interrupta*	8	21	20
				Myrica cerifera	6	32	17
				Sarcostemma clausum	4	75	16
				Peltandra virginica	5	39	14
				Saururus cernuus	2	75	11
				Blechnum serrulatum	4	21	10
				Pontederia cordata	2	50	10
Sparse Sawgrass	16%	56	27%	*Cladium jamaicense* (live)	26	100	55
				Cladium jamaicense (dead)	7	87	21
				Bacopa caroliniana	6	54	15
				Eleocharis interstincta	6	38	14
Dense Sawgrass	16%	26	27%	*Cladium jamaicense* (live)	61	100	93
				Cladium jamaicense (dead)	30	99	59
Decadent Sawgrass	26%	21	92	*Cladium jamaicense* (dead)	55	100	88
				Cladium jamaicense (live)	33	100	64
Wet Prairie	11%	52	79%	*Eleocharis cellulosa*	26	82	43
				Panicum hemitomon	10	76	21
				Periphyton	8	51	13
				Bacopa caroliniana	6	51	13
				Utricularia foliosa	6	51	13
Slough	11%	36	91%	*Bacopa carolina*	56	100	74
				Eleocharis cellulosa	10	74	19
				Periphyton	8	74	18

Table 11-4. Relative assemblage frequency, total species richness, and mean total cover of all species, for plant assemblages on the South Island. Mean cover (%), relative frequency (%) and importance value of dominant species are also given.

Assemblage	Frequency	Total Species Richness	Mean Total Cover:	Dominant Species	Cover (%)	Frequency (%)	Importance
Dry Forest	5%	24	88%	*Chrysobalanus icaco*	69	100	97
				Myrica cerifera	7	47	16
Wet Forest	11%	31	75%	*Chrysobalanus icaco*	29	95	51
				Dead-wood	20	95	39
				Salix caroliniana	6	79	17
Forest Fern	5%	24	62%	*Chrysobalanus icaco*	15	100	39
				Blechnum serrulatum	13	94	35
				Salix caroliniana	6	88	22
				Annona glabra	18	53	18
Sparse Sawgrass	26%	36	71%	*Cladium jamaicense* (live)	10	74	24
				Peltandra virginica	11	66	23
				Cladium jamaicense (dead)	7	57	17
				Utricularia purpurea	6	59	16
				Periphyton	5	55	13
				Nymphaea odorata	4	54	12
Dense Sawgrass	14%	22	77%	*Cladium jamaicense* (live)	50	100	89
				Cladium jamaicens e(dead)	18	100	47
Decadent Sawgrass	16%	20	87%	*Cladium jamaicense* (live)	50	100	89
				Cladium jamaicens e(dead)	18	100	47
Slough	23%	25	76%	*Nymphaea odorata*	35	100	61
				Utricularia purpurea	23	90	43

Although many of these assemblages were dominated by different species on North Island and South Island, they are, in fact, analogous assemblages based on the relative elevations at which they are found on these islands (Table 11-5). For example, on North Island the highest areas on the head were dominated by *S. terebinthifolius,* while on South Island *C. icaco* was the dominant species at the highest elevations. On both islands, *Myrica cerifera* L. was the next most abundant species at the highest elevations. Because these assemblages are ecologically equivalent, they are both classified as dry forest. (It should be noted that dry forest as used here is a relative term and that the "dry" forest on these two low elevation islands can be flooded much of the time during most years.) The other two comparable forested assemblages on North Island and South Island are also dominated by different tree species. The wet forest and forest-fern assemblages on North Island are dominated by *M. cerifera* while those on South Island are again dominated by *C. icaco.* Likewise, comparable non-tree assemblages on the two islands often have different dominants (Tables 11-3 and 11-4).

Table11- 5. Mean (standard deviation) of bedrock elevation, peat elevation and peat thickness for each plant assemblage on North Island and South Island. Significant differences among means are as indicated by different letters ($p \leq 0.05$).

Plant Assemblages	N	Bedrock Elevation (cm)	Peat Elevation (cm)	Peat Thickness (cm)
North Island				
Dry forest	27	333 (16.4) e	355 (10.1) c	25 (11.1) a
Wet forest	16	319 (16.9) de	345 (8.9) b	28 (14.0) a
Forest-fern	28	305 (30.4) d	341 (16.9) b	37 (18.1) ab
Sparse Sawgrass	61	280 (30.4) a	323 (9.5) a	42 (21.7) ab
Sawgrass-Cattail	43	270 (30.3) a	323 (7.1) a	52 (29.7) b
Dense Sawgrass	79	226 (45.7) b	321 (7.6) a	96 (39.6) c
Decadent Sawgrass	127	250 (38.1) c	319 (7.2) a	70 (37.2) d
Wet Prairie	51	271 (32.4) a	324 (10.9) a	52 (27.5) b
Slough	50	283 (21.1) a	319 (5.9) a	38 (15.5) ab
South Island				
Dry forest	17	233 (39.6) c	298 (24.4) d	62 (21.1) b
Wet forest	42	151 (16.6) a	270 (8.6) c	119 (10.5) c
Forest-fern	17	205 (15.1) b	266 (17.9) c	67 (12.8) b
Sparse Sawgrass	102	153 (18.8) a	248 (11.6) b	96 (18.7) a
Dense Sawgrass	55	150 (11.6) a	248 (7.2) b	96 (12.1) a
Decadent Sawgrass	62	149 (8.8) a	251 (7.2) b	101 (10.1) a
Slough	91	147 (12.6) a	239 (12.4) a	93 (15.1) a

The dominant species of each plant assemblage found on North Island are given in Table 11-3. Distributions of these plant assemblages along transects across North Island are shown in Figure 11-3. Forest-fern, dry-forest and wet-forest assemblages were confined to the highest elevations of the heads. *M. cerifera* L. was a dominant component of all three assemblages, but was most abundant in the wet-forest assemblage. Two fern species, *Thelypteris interrupta* (Willd.) K. Iwats. and *Blechnum serrulatum* Rich. dominated the understory in the forest-fern assemblage. Forested vegetation occurred in only 16% of the quadrats sampled.

Four plant assemblages were dominated in part by *C. jamaicense* (Table 11-3): sawgrass-cattail, dense sawgrass, sparse sawgrass and decadent sawgrass. These differed in amounts of live and dead sawgrass, sawgrass density and height, and associated species. Two other assemblages present were wet prairie and slough. Wet prairie was dominated by the aquatic emergent species, *Eleocharis cellulosa* Torr. and *Panicum hemitomon* Schult. and by submersed and floating species, *Bacopa caroliniana* (Walter) B.L. Rob. and *Utricularia foliosa* L., respectively. The slough assemblage was dominated by *B. caroliniana* and *E. cellulosa.* Slough vegetation was found adjacent to the head and a mixture of slough and wet prairie vegetation occurred adjacent to and in the tail (Figure 11-3). Decadent sawgrass was present in a zone on the western fringe of the head and near tail, and was intermixed with other assemblages on the far tail. Sawgrass-cattail and wet prairie were common along the central portion of transect 6. Intermingling zones of dense sawgrass and decadent sawgrass were centrally located on the near tail. Decadent sawgrass and dense sawgrass occurred in 42% of the quadrats sampled (Table 11-3).

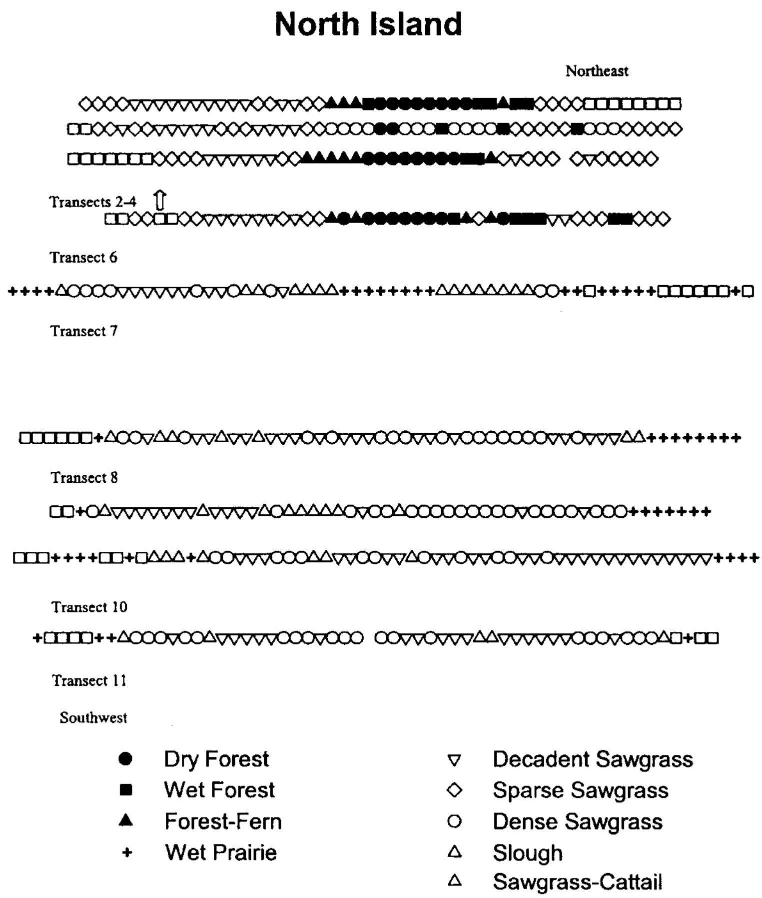

Figure 11-3. Distribution of plant assemblages (see Table 11-3 and text) along North Island's transects. Each symbol represents a linear distance of 4 meters. The studied portion of the island was defined by a 122 m x 138 m rectangle (transects 2-4, head; transects 6-8, near tail; transects 9-11, far tail).

Seven plant assemblages were found on South Island. The dominant species of each assemblage are given in Table 11-4. The distributions of these assemblages along transects across the island are shown in Figure 11-4. Forested assemblages were confined to the head (forest-fern and dry forest) and near tail (wet forest). Dry forest, which occurred only at the highest elevations, was dominated by *C. icaco* and *M. cerifera*. Forest-fern and wet forest occurred at slightly lower elevations than dry forest. The dominants of the forest-fern assemblage were *B. serrulatum*, *C. icaco*, *Salix* *caroliniana* Michx. and *A. glabra*. *C. icaco* and *S. caroliniana* were dominants in the wet forest. Forested vegetation occurred in only 21% of quadrats sampled.

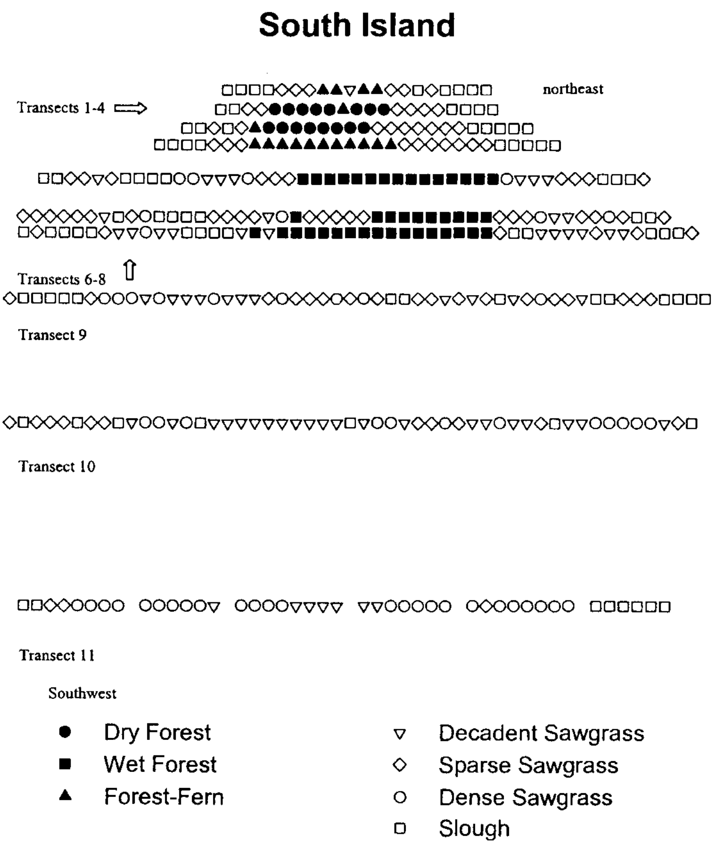

Figure 11-4. Distribution of plant assemblages (see Table 11-4 and text) along South Island's transects. Each symbol represents a linear distance of 4 meters. The studied portion of the island was defined by a 104 m x 574 m rectangle (transects 1-4, head; transects 6-8, near tail; transects 9-11, far tail).

Three assemblages dominated by *C. jamaicense* were found: dense sawgrass, sparse sawgrass and decadent sawgrass. The decadent sawgrass and dense sawgrass assemblages were similar to those described for North Island. The sparse sawgrass on South Island was characterized by small stature *C. jamaicense* (live) as on North Island, but the co-dominants were *Peltandra virginica* (L.) Schatt and Endl. *Utricularia purpurea* Walter, periphyton and *Nymphaea odorata* Sol. The slough assemblage was dominated by *N. odorata* and *U. purpurea*. Sparse sawgrass and slough represented 49% of the surveyed area (Table 11-4). Slough and sparse sawgrass were found on the margins of the island's head and tail. The near tail was covered with wet forest and the central portion of the far tail by intermingling zones of decadent sawgrass and dense sawgrass.

3.4 Vegetation and Topography

On North Island, mean bedrock elevation (Table 11-5) was highest under dry forest (333 cm), slightly lower under wet forest and forest-fern (305 to 319 cm) and lowest under decadent sawgrass (250 cm) and dense sawgrass (226 cm). Bedrock elevation was similar under slough, wet prairie, sparse sawgrass and sawgrass-cattail (270 to 283 cm). Mean peat elevation was highest at the dry forest (355 cm) and wet forest and forest-fern (341 to 345 cm), and lower for all other assemblages (319 to 324 cm). The peat layer was thinnest at the three forest assemblages as well as the slough and sparse sawgrass (25 to 42 cm). The peat layer was thickest at the decadent sawgrass assemblage (96 cm).

Bedrock elevations on South Island (Table 11-5) were highest under the dry forest (233 cm), slightly lower under the forest-fern (205 cm) and were only 147 to 153 cm for the other assemblages. The peat elevations again were highest at the dry forest (298 cm), slightly lower under the forest-fern and wet forest and lowest under the slough (239 cm). The peat layer was thinnest under the forest-fern and dry forest (62 to 67 cm), thickest under the wet forest (119 cm) and ranged from 93 to 101 cm under the other assemblages.

4. DISCUSSION

Our results are consistent with the hypothesis that fixed tree islands have heads that are underlain by topographic highs in the bedrock. Peat elevation differences between heads and tails of these islands, however, are smaller than those between bedrock elevations of the heads and tails. This is because the peat layer is thinner over the heads. In spite of the rather small differences in peat elevation between heads and tails, this difference is obviously great enough to affect the kinds of plant assemblages found on the heads and tails. The primary difference between the vegetation on the heads and tails is the presence of tree and shrub species on the heads that are dense enough to form at least an open canopy layer, although different dominant woody species were found on each island. Our results raise several questions. One, what controls the distribution of plant species on an island? Two, why is the peat layer thinnest on the heads? Three, why are there different dominant woody species on the islands?

Water depth and duration of flooding are postulated to be primary factors responsible for the vegetation mosaic found in the Everglades (Gunderson 1994; McPherson 1973; David 1996; Goodrick 1984; Olmsted and Armentano 1997). The mean peat elevation difference for forested and non-forested assemblages is only 26 cm on North Island and 31 cm on South Island. Small differences in elevation on these islands have significant consequences for an island's biota as reflected in the vegetation. For forested assemblages, depth and duration of flooding, as reflected here by peat elevation, seems to be responsible for the distribution of the three forested assemblages. Peat elevation, however, is poorly, if at all, correlated with the distribution of non-forested assemblages. Environmental or biotic factors that control the distribution of non-forested assemblages need study.

Whether the thinner layer of peat on the heads is the result of higher oxidation rates of peat, or is due to greater frequency of fires on the heads when the heads are not flooded, is not known. It is also possible that peat deposition rates are simply low in forested versus non-forested vegetation types. The latter seems unlikely as the sole mechanism because only rarely on either island was a peat elevation on a tail as high or higher than on the head. In any case, our results suggest that there seems to be a mechanism that limits the maximum height of fixed tree islands in the Everglades. If this is so, it has significant implications for managing water levels and the restoration of tree islands in the Everglades. That tree islands are unable to increase their elevations when water levels are raised is suggested by the loss of tree islands in WCA-2A. WCA-2A lost over 80% of its tree islands between 1953 and 1980, due to prolonged periods with higher water levels (Hofmockel 1999). Peat accumulation rates on the heads and tails of tree islands are topics that need to be studied in detail, especially why peat elevations in the tails seem to be unable to exceed those on heads.

Peat thickness has been associated with occurrences of non-forested vegetation types in the Everglades (Meeder et al. 1996). The South Florida Water Management District (1992) reported that dense-sawgrass occurs in areas of peat thickness greater than 1m and sparse-sawgrass occurs where peat deposits were less than 1m. However, David (1996) suggested that significant differences in soil depths among vegetation types were of no consequence in determining the position of vegetation types. Olmstead and Armentano (1997) reported dense-sawgrass underlain by peat ranging from 48 to 88cm in thickness and sparse-sawgrass underlain by 34 to 69 cm of peat. As with peat elevation, our data suggest that peat thickness was not strongly associated with occurrences of non-forested assemblages. Whether the shallower peat layer on the heads is advantageous for the establishment, growth or persistence of trees is not known. Many of the larger trees on heads appear to have roots that penetrate the limestone bedrock. This may make them more resistant to toppling during high winds and may allow them to obtain nutrients from the bedrock that may be in short supply in the peat.

There are many possible explanations for the differences in dominant tree species between islands. The four that seem most likely are vagaries of seed dispersal, frequency of freezing, fire history, and competitive exclusion by exotic species. Little is known about how often seeds of woody species reach tree islands. It is noteworthy that all of the dominant tree species have either fleshy fruits that are undoubtedly bird dispersed or have wind dispersed seeds. Where seeds are deposited as results of either bird or wind dispersal is difficult to predict. For example, the composition of the vegetation that re-established on islands denuded by the eruption of Mt. Krakatau in Indonesia varied from island to island, and this seems to be primarily the result of the vagaries of seed dispersal (Whittaker et al. 1989). North Island is approximately 35 miles north of South Island. Frequency of freezing increases with latitude. Consequently, the probability of occurrence of temperate species in Florida vegetation increases with latitude (Egler 1952; Craighead 1971; Olmsted et al. 1993). In fact, the number of tropical species on North Island was lower than on South Island. Severe peat fires were common in the central portion of WCA-3A during the 1970's (Schortemeyer 1980; Zaffke 1983) and exposed bedrock on North Island suggests that this island has experienced a recent fire. Fire is an important factor determinant of composition and distribution of nearly all Everglades vegetation (Robertson 1954; Craighead 1971; Hofstetter and Parsons 1975; Hofstetter 1984; Wade et al. 1980; Herndon et al. 1991). *S. terebinthifolius* is an introduced tree from Brazil that has become a major weed problem in South Florida. Its seeds are readily dispersed by birds and small mammals and it will rapidly colonize areas following disturbance (Hofstetter 1984). After establishment, *S. terebinthifolius* will form dense monotypic stands that can displace native species (Alexander and Crook 1974). In short, any one of these factors or some combination of them could be responsible for differences in species composition between North Island and South Island.

In summary, the results of our study indicate that heads are underlain by topographic highs in the bedrock and that they also have the highest peat elevations. These slightly higher elevations allow forested vegetation types to develop and survive on these islands. Causal factors controlling the distribution of non-forested vegetation on the tails of these islands remain obscure, but their distribution does not seem to be related strongly to elevation differences. The thinner layer of peat on the heads of tree islands suggests that some unknown mechanism controls the maximum elevation of peat on an island. Until additional studies of the entire tree island are undertaken, it is uncertain whether our picture of the vegetation and geomorphology of fixed tree islands is representative or not.

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